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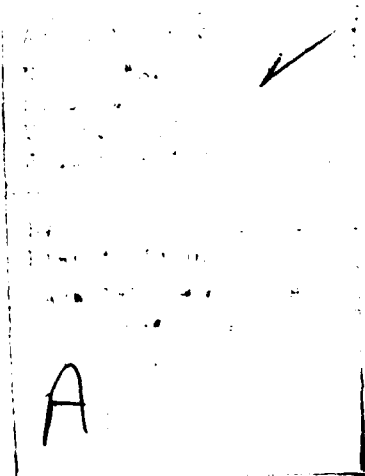
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I dedicate this thesis to my wife Rebecca who skillfully typed this paper and who has constantly encouraged me during my graduate studies.

D.B.S.

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## INTRODUCTION

The ultimate goal of conventional root canal therapy is the retention of the treated tooth as a functional member of the masticatory system with healthy periapical and periodontal tissues. The dentist must reduce or eliminate toxic or irritating substances from within the root canals to levels within the physiologic limits of repair of each patient.<sup>1</sup>

Although root canal therapy has a high success rate, all cases are not successful, and practitioners must continue to examine their treatment results to eliminate any variables which can contribute to failure.

An evaluation of treatment results during a twenty-year period at the West Virginia University School of Dentistry was conducted to calculate the success to failure ratio and to identify those variables which can affect the treatment prognosis.

### PURPOSE

The purpose of this study is to determine the degree of success or failure of conventional root canal therapy performed at West Virginia University School of Dentistry from 1959 to 1979.

## REVIEW OF LITERATURE

"The Washington Study" by Ingle<sup>2,3</sup> is the classic study regarding success and failure of endodontic therapy. Ingle reported a success rate of 91.54% in evaluating two-year recall radiographs of 1,229 cases completed during the mid-1950's. It is important to note that 34.25% of these cases were treated surgically, but no significant difference was found between conventional and surgical treatment results. Ingle judged successful those cases with "decided periapical improvement" or "continuing periapical health" as interpreted from the recall radiographs. Cases with no periapical improvement or cases which developed new or larger lesions were judged as failures. No significant differences in the success rates were found when comparing cases according to the age or sex of the patient or when comparing the types of teeth being treated. It is interesting that 45.88% of the cases were maxillary anteriors in which successful treatment may be easier to achieve than in multicanal teeth. "The Washington Study" was the first comprehensive investigation comparing success and failure of endodontic therapy.

In 1957, Strindberg<sup>4</sup> reported there was no appreciable difference in the success rate of root canal therapy based on the age or systemic health of 254 patients recalled for clinical and radiographic examinations. Strindberg did report a lower success rate when a periapical rarefaction

was originally present, when broken instruments were used to seal the canals, and when a pronounced overfill was present.

Bender and Seltzer<sup>5</sup> called attention to the problem of evaluating success and failure based on radiographic evidence alone. By creating bony defects in cadaver mandibles and comparing radiographs of these defects with direct visualizations of the defects, they were able to report that the size of a radiographic rarefaction does not correlate with the actual amount of bone destruction. Lesions in cancellous bone were not radiographically visible. Since large cancellous bony defects may be present with no radiographic evidence of their presence, studies on success and failure based solely on radiographic evidence may not accurately describe the successful healing of the bony lesions.

Another large study on success and failure was reported by Grahén and Hansson in 1961.<sup>6</sup> They evaluated 1,277 roots which were treated in 1952 and evaluated five years later in 1957. They found an overall failure rate of 12% with another 6% having an uncertain prognosis. They agreed with Strindberg's<sup>4</sup> decision that cases should not be evaluated for success or failure until four or more years after obturation.

In 1963, Nicholls<sup>7</sup> published his paper concerning radiographic evaluation of the periapical status of

pulpless teeth. He differed with Bender and Seltzer<sup>5</sup> in reporting that the radiograph will usually demonstrate periapical bone destruction resulting from chronic periapical disease. Nicholls stressed that a two-year recall period is adequate for evaluating endodontic success and that success should be based on the radiographic presence of a periodontal membrane space of approximately even width around the entire root end. He did not believe that a definite lamina dura must be present for a case to be considered successful. Assuming the obturation material is not disturbed, complete bone reconstruction following endodontic therapy is permanent according to Nicholls' findings.

Zeldow and Ingle<sup>8</sup> reported a two-year success rate of 83.3% for 89 single canal teeth which were filled with a positive culture. They summarized that teeth filled with a negative culture have success rates ranging as high as 96%. Their definition of success was based on two-year clinical and radiographic exams showing decided periapical improvement or constant periapical health plus a negative posttreatment history.

Bender, Seltzer, and Freedland<sup>9</sup> cautioned against failures caused by misdiagnosis rather than poor local treatment. Dentists must be aware that root canal therapy will not resolve lesions such as multiple myelomas, Histiocytosis X diseases, giant cell granulomas, traumatic

bone cysts, or globulomaxillary cysts. Systemic disease such as diabetes can retard healing as can the systemic administration of steroids for long periods of time. Proper diagnosis including a thorough health history is necessary to avoid these predictable causes of failure.

Another excellent study concerning the success or failure of root canal therapy in 2,921 teeth was published by Seltzer, Bender, and Turkenkopf in 1963.<sup>10</sup> Success was defined as the absence or diminution of regions of rarefaction six months after filling the canals. The authors concluded that successful repair was achieved in 80% or more of the teeth at all age levels with a slightly higher success rate for those patients under 20 years of age. Success was based on radiographic evidence alone and the authors reported a lower success rate for teeth with a preexisting rarefaction. Success was achieved in 92% of the teeth without a rarefaction, while only 76% success was achieved in the teeth with rarefactions. The authors noted a much better prognosis for teeth with flush fills or underfills as compared to overfills when a rarefaction was present.

In 1964, Grossman, Shepard, and Pearson<sup>11</sup> reported 89.3% success for necrotic pulp cases as compared to 90.4% success for vital pulp cases. This study includes an excellent summary of previously published success rates for endodontic therapy ranging from 48% to 99%. The

authors stressed that the definition of success or failure in evaluating therapy has an enormous effect on the rates of success found by various investigators. This study included a "doubtful" classification for those cases in which an area of rarefaction had become smaller, but in which bone repair was incomplete.

In 1966, Bender, Seltzer, and Soltanoff<sup>12</sup> concentrated on the problems of evaluating success and failure using radiographic interpretation only. The authors emphasized that there was no proof that a normal radiographic appearance correlates with normal histologic appearance of the periapical tissues. There was no correlation determined between clinical symptoms and the histology of the apical tissues. This study found that only 39.2% of 365 teeth with previous areas of rarefaction had undergone complete bone regeneration after two to ten years. Problems with radiographic evaluation include variation of horizontal and vertical cone angulations and evidence that 50% of the bone must be decalcified before a lesion is evident on the radiograph. The authors listed the following suggested criteria for success: 1) absence of pain or swelling; 2) disappearance of fistulas; 3) no loss of function; 4) no evidence of tissue destruction; and 5) radiographic evidence of an eliminated or arrested area of rarefaction six months to two years after obturation. Failures usually are detected radiographically within two years and

clinical symptoms usually develop within the first few months after treatment.

Another study reporting 146 failures was published by Seltzer et al<sup>13</sup> in 1967. They confirmed that most failures occur within twenty-four months and that teeth with areas of rarefaction failed more frequently by a ratio of two and one-half to one. They deviated from previous studies by stating, "regardless of the roentgenographic interpretation, endodontically treated teeth which are functioning adequately and without adverse clinical symptoms should be regarded as successfully treated."

Storms<sup>14</sup> published a one-year follow-up study of 158 teeth receiving endodontic treatment and reported an increased success rate in the older age groups of the patients. This finding disagreed with the findings of others<sup>2,3,4</sup> who reported no differences in success according to the age of the patient. The author emphasized that obturation with silver points was 100% successful when the points were 0.5 to 3.0 millimeters short of the apex. Overfills with silver points were associated with a higher failure rate, possibly caused by mechanical irritation of the periapical tissues.

In 1970, Heling and Tomshe<sup>15</sup> reported 71% success in single canal teeth and 68.3% success in multicanal teeth. They evaluated 213 teeth with posttreatment intervals ranging from one to five years. Their definition of success

required total bone regeneration and this may have been responsible for their low success rates.

The difficulty of detecting periapical bone lesions in the mandible was reconfirmed by Schwartz and Foster<sup>16</sup> in a study very similar to the earlier work of Bender and Seltzer.<sup>5</sup> Both authors emphasized that no bony lesions will be visible on radiographs until the cortical bone has been eroded. The study of Schwartz and Foster recorded lesions of both the maxilla and mandible, whereas the study of Bender and Seltzer dealt exclusively with bony defects in the mandible.

Goldman, Pearson, and Darzenta<sup>17</sup> published an excellent study regarding the problem of relying on radiographic interpretation to determine endodontic success or failure. The study emphasized that radiographs are interpreted and radiographs cannot be "read" like a book. Radiographs of 253 endodontic cases were interpreted by six different examiners. Preoperative and six-month recall films were examined independently by the six examiners and their results were compared. All six examiners were able to agree on the success or failure of less than one-half of the 253 cases. Even when the question was determining whether an area of rarefaction was or was not present on one film, the six examiners still were able to agree on less than one-half of the cases. The cases causing the most disagreement among the examiners were

the maxillary molars. The study graphically illustrated that radiographic evaluation of endodontic success or failure is a very difficult and, at times, arbitrary decision.

A follow-up study by Goldman et al<sup>18</sup> was published in 1974 involving the 253 endodontic cases from their earlier study.<sup>17</sup> Three of the previous six examiners reevaluated the 253 cases six to eight months after the initial evaluations without the knowledge of their previous evaluations. The examiners agreed with their previous findings from 72% to 88% of the time, further demonstrating the difficulty in evaluating success and failure using radiographs.

A recent study of Kerekes and Tronstad<sup>19</sup> demonstrated a success rate of 91% using Ingle's standardized technique. They concluded that roots without a rarefaction had a significantly better prognosis than roots with a preexisting rarefaction.

In 1980, an evaluation of 566 cases of root canal therapy completed in a general practice was published by Barbakow et al.<sup>20,21</sup> The authors judged the case as successful when the patient was without symptoms, the tooth was not tender to percussion, and no radiographic abnormalities were present. An overall success of 87.4% was obtained; however, success of the mandibular molars was less than 65% with a large number of questionable results.

The cases were evaluated after a minimum recall period of one year. This study revealed the lowest success rate in canals filled short of the radiographic apex. The best results were obtained in canals filled to the radiographic apex. Previous studies<sup>4,10,14</sup> agreed that overfills were associated with highest failure rates while underfills were associated with the highest success rates.

## MATERIALS AND METHODS

Patients receiving root canal therapy at the West Virginia University School of Dentistry are recalled at intervals of six months, one year, two years, five years, and ten years for radiographic evaluation of their endodontically treated teeth. Prior to exposure of recall radiographs, patients are questioned to determine if the involved teeth are symptomatic. Recall radiographs are placed in the patient's individual treatment packet, and the patient's response concerning any clinical symptoms is recorded. These recall records were evaluated to determine the success or failure of conventional root canal therapy cases completed from 1959 to 1979. Only those cases with a recall radiograph taken one or more years after completion of therapy were evaluated. A total of 1,007 teeth with 1,770 canals were evaluated for success or failure.

Patient film packets with recall radiographs were grouped according to the length of the recall period — one year, two years, three years, and five or more years. The minimum recall period of one year was selected since one-year recall films are currently accepted by the American Board of Endodontics when an endodontist submits cases for specialty board certification.<sup>22</sup> Bender et al<sup>12</sup> have reported that teeth with rarefactions show no significant difference in success rates when comparing

six-month recall radiographs with two-year recall radiographs. Although lesions are occasionally not completely recalcified at the one-year interval, it is possible to determine if the lesion is smaller, larger, or unchanged in size one year after obturation.

Each case was evaluated for success or failure by examining the recall radiograph(s) and by checking the patient's treatment packet to see if the patient reported any clinical symptoms prior to exposure of the recall radiograph(s).

In addition to evaluation of success or failure, the following data was recorded for each tooth:

1. Sex and age of the patient at the time of treatment.
2. Tooth number.
3. Number of canals treated.
4. Presence or absence of a proper restoration at the time of the recall.
5. Type of filling material.
6. Presence or absence of preexisting pathology.
7. Apical termination of the filling material.

The majority of these cases were completed by predoctoral dental students under direct endodontic faculty supervision at the West Virginia University School of Dentistry. A small number of these cases were completed by faculty members. The teeth were treated using standardized endodontic techniques, and, with few exceptions,

the canals were filled three to seven days after obtaining a negative culture.

All the data was categorized and tabulated with regard to the anatomical types of teeth so the frequency of treatment and success rate for each type of tooth could be readily determined. The number of canals treated in each case was recorded to facilitate determination of the numbers of canals treated in the various types of teeth.

Prior to evaluation of the cases, criteria to determine success or failure were selected. The criteria for success or failure as published by Bender et al<sup>12</sup> were selected as being most appropriate for current usage. The criteria take into consideration clinical symptoms rather than relying entirely on a radiographic interpretation. Cases were considered successful when the following criteria were met:

1. Absence of pain or swelling.
2. Disappearance of any fistulas.
3. No loss of function.
4. No evidence of tissue destruction.
5. Radiographic evidence of resolved or arrested areas of pathology after a posttreatment interval of six months to two years.

The following criteria were used to determine failures:

1. Presence of pain, swelling, or fistula.
2. Loss of function.

3. Preexisting periapical pathology that increases in size or does not decrease in size after obturation.
4. Development of periapical pathology where no pathology was originally present.

The sex and age in decades for each patient were recorded to determine if age or sex had any correlation with success or failure. The type of filling material (gutta-percha or silver) and the apical termination (overfill, underfill, flush fill) of the filling material were recorded for each canal. The presence or absence of preexisting pathology was recorded for each root treated.

Recall radiographs were also evaluated for the presence of a proper restoration. Weine<sup>23</sup> has stated, "a greater number of endodontically treated teeth are lost because of fracture due to improper restorations than because of poor endodontic results". Cameron<sup>24</sup> has also reported some of the problems with cracked teeth and with untreatable vertical fractures. The endodontic access opening disrupts roof arch continuity of the pulp chamber thus compromising the strength of the tooth. A proper restoration should provide cuspal protection to the posterior teeth. Anterior teeth with mesial and/or distal carious lesions or restorations should be restored with a dowel post and full coverage crown. Anterior teeth with no crown damage other than the access opening can be conservatively restored using composite restorative materials.

A proper restoration should be considered an integral part of good endodontic therapy.

Recall radiographs were examined by the primary investigator using a viewbox and magnifying glass and the data recorded for 1,007 teeth with 1,770 canals. Chi-square analysis was used to determine if any variable significantly affected the success rate for these cases.

## RESULTS

A successful evaluation was recorded for 89.66% of the 1,770 canals treated. Since failure of one canal of a multicanal tooth resulted in case failure, the success rate of the 1,007 cases was slightly lower at 87.79% success.

Chi-square analysis was performed comparing the success of each tooth type with the success of the remaining teeth. The analysis of success and failure by the individual tooth type revealed that only mandibular first molars had a significantly lower success rate when compared to the success rate of the other teeth. A chi-square value of 5.78 was recorded for mandibular first molars; this value is greater than the value of 3.84 required to rule out chance at the five percent significance level with one degree of freedom. All other tooth types yielded chi-square values well below the critical value of 3.84. The analysis according to individual tooth type is summarized in Table 1.

Analysis of success and failure according to the age of the patient at the time of treatment revealed no significant difference among the various age groups. The chi-square values for all of the age groups were below the critical value of 3.84. The analysis of success and failure by age of the patient is summarized in Table 2.

TABLE 1

Analysis of Success and Failure By Individual Tooth

<u>Tooth</u>	<u>Number of Cases</u>	<u>Number of Successes</u>	<u>% Successes</u>	<u>Number of Failures</u>	<u>% Failures</u>	<u>Frequency of Treatment</u>	<u><math>\chi^2</math></u>
<u>Maxillary</u>							
Central Incisors	153	140	91.50	13	8.50	15.19	2.33
Lateral Incisors	158	143	90.51	15	9.49	15.69	1.29
Canines	39	34	87.18	5	12.82	3.87	0.01
1st Premolars	75	69	92.00	6	8.00	7.45	1.34
2nd Premolars	79	65	82.28	14	17.72	7.85	2.43
1st Molars	100	88	88.00	12	12.00	9.93	0.01
2nd Molars	<u>34</u>	<u>31</u>	<u>91.18</u>	<u>3</u>	<u>8.82</u>	<u>3.38</u>	0.38
TOTAL	638	570	89.34	68	10.66	63.36	
<u>Mandibular</u>							
Central Incisors	56	48	85.71	8	14.29	5.56	0.24
Lateral Incisors	21	18	85.71	3	14.29	2.09	0.09
Canines	13	12	92.31	1	7.69	1.29	0.25
1st Premolars	47	41	87.23	6	12.77	4.67	0.01
2nd Premolars	52	48	92.31	4	7.69	5.16	1.05
1st Molars	135	110	81.48	25	18.52	13.40	5.78
2nd Molars	<u>45</u>	<u>37</u>	<u>82.22</u>	<u>8</u>	<u>17.78</u>	<u>4.47</u>	1.36
TOTAL	369	314	85.09	55	14.91	36.64	
TOTAL NUMBER OF TREATED CASES	1,007	884	87.79	123	12.21	100%	

TABLE 2

Analysis of Success and Failure By Age

<u>Age</u>	<u>Number of Cases</u>	<u>Number of Successes</u>	<u>% Successes</u>	<u>Number of Failures</u>	<u>% Failures</u>	<u><math>\chi^2</math></u>
Under 10	8	7	87.50	1	12.50	0.001
10 - 19	316	280	88.61	36	11.39	0.29
20 - 29	297	263	88.55	34	11.45	0.23
30 - 39	143	119	83.22	24	16.78	3.24
40 - 49	139	124	89.21	15	10.79	0.31
50 - 59	65	56	86.15	9	13.85	0.17
60 - 69	31	27	87.10	4	12.90	0.01
70 - 79	<u>8</u>	<u>8</u>	<u>100.00</u>	<u>0</u>	<u>0.00</u>	1.12
TOTAL	1,007	884	87.79	123	12.21	

An analysis of success and failure according to the sex of the patient revealed that males had a significantly lower success rate than the females in this study. A chi-square value of 7.25 was larger than the critical value of 3.84 needed to rule out chance at the five percent level with one degree of freedom. The success rate for males was 84.70% compared to 90.29% for females. The analysis of success and failure according to the sex of the patient is summarized in Table 3.

TABLE 3  
Analysis of Success and Failure By Sex

<u>Sex</u>	<u>Number of Cases</u>	<u>Number of Successes</u>	<u>% Successes</u>	<u>Number of Failures</u>	<u>% Failures</u>
Male	451	382	84.70	69	15.30
Female	<u>556</u>	<u>502</u>	<u>90.29</u>	<u>54</u>	<u>9.71</u>
TOTAL	1,007	884	87.79	123	12.21

$$\chi^2 = 7.25$$

Success and failure comparing the type of filling material revealed no significant difference in success when comparing gutta-percha and silver filling materials. Although the success rate of silver was slightly lower at 88.44% as compared to 91.23% for gutta-percha, a chi-square value of 3.64 was below the critical value of 3.84. The analysis of success and failure by filling material is summarized in Table 4.

TABLE 4  
Analysis of Success and Failure By Filling Material

<u>Filling Material</u>	<u>Number of Canals</u>	<u>Number of Successes</u>	<u>% Successes</u>	<u>Number of Failures</u>	<u>% Failures</u>
Gutta-Percha	775	707	91.23	68	8.77
Silver	<u>995</u>	<u>880</u>	<u>88.44</u>	<u>115</u>	<u>11.56</u>
TOTAL	1,770	1,587	89.66	183	10.34

$$\chi^2 = 3.64$$

Analysis of success and failure considering the presence of preexisting pathology revealed that cases with preexisting pathology had a much lower success rate. Cases with pathology had a success rate of 82.91% compared to a success rate of 94.22% in cases with no pathology. The chi-square value was 58.78 which greatly exceeds the critical value of 3.84. Thus, it can be concluded that cases with preexisting pathology have a significantly lower success rate than cases with no preexisting pathology. A summary of this analysis is presented in Table 5.

TABLE 5  
Analysis of Success and Failure -  
Presence or Absence of Preexisting Pathology

	<u>Number of Canals</u>	<u>Number of Successes</u>	<u>% Successes</u>	<u>Number of Failures</u>	<u>% Failures</u>
Preexisting Pathology	714	592	82.91	122	17.09
No Pathology	<u>1,056</u>	<u>995</u>	<u>94.22</u>	<u>61</u>	<u>5.78</u>
TOTAL	1,770	1,587	89.66	183	10.34

$$\chi^2 = 58.78$$

When the success and failure rates were analyzed according to the apical termination of the filling material, two significant differences were found. Overfills were found to have a significantly lower success rate than underfills (chi-square of 99.02) and overfills had a significantly lower success rate than flush fills (chi-square of 34.19). No significant difference in the success rate was found when comparing flush fills and underfills (chi-square of 1.11). The critical value was 3.84. The analysis according to the apical termination of the filling material is summarized in Table 6.

TABLE 6  
Analysis of Success and Failure -  
Apical Termination of Filling Material

Apical Termination	Number of Canals	Number of Successes	% Successes	Number of Failures	% Failures
Over	123	78	63.41	45	36.59
Under	1,432	1,316	91.90	116	8.10
Flush	<u>215</u>	<u>193</u>	<u>89.77</u>	<u>22</u>	<u>10.23</u>
TOTAL	1,770	1,587	89.66	183	10.34

Comparison of Overfill versus Underfill  $\chi^2 = 99.02$   
 Comparison of Overfill versus Flush Fill  $\chi^2 = 34.19$   
 Comparison of Flush Fill versus Underfill  $\chi^2 = 1.11$

Each case was evaluated for the placement of a proper restoration. An analysis of success and failure considering the presence of a proper restoration revealed there was a significantly lower success rate when no proper restoration

was placed. The chi-square value of 13.65 was higher than the critical value of 3.84 and it can be concluded that placement of a proper restoration is conducive to a higher success rate. Table 7 summarizes this analysis with regards to the placement of a proper restoration.

TABLE 7  
Analysis of Success and Failure -  
Posttreatment Restoration

	<u>Number of Cases</u>	<u>Number of Successes</u>	<u>% Successes</u>	<u>Number of Failures</u>	<u>% Failures</u>
Proper Restoration	451	415	92.02	36	7.98
Not Properly Restored	<u>556</u>	<u>469</u>	<u>84.35</u>	<u>87</u>	<u>15.65</u>
TOTAL	1,007	884	87.79	123	12.21

$$\chi^2 = 13.65$$

The analysis of success and failure with regard to the length of the recall period revealed a significant difference for the one-year and three-year recall periods when comparing them to the other recall periods. The success rate for the one-year recall period was significantly lower (chi-square of 5.59) than the other recall periods. The success rate for the three-year recall period was significantly higher (chi-square of 6.05) than the other recall periods. The analysis according to the length of the recall period is summarized in Table 8.

TABLE 8  
Analysis of Success and Failure - Length of Recall

<u>Length of Recall</u>	<u>Number of Cases</u>	<u>Number of Successes</u>	<u>% Successes</u>	<u>Number of Failures</u>	<u>% Failures</u>	<u><math>\chi^2</math></u>
1 year	530	453	85.47	77	14.53	5.59
2 years	222	195	87.84	27	12.16	0.001
3 years	158	148	93.67	10	6.33	6.05
5 years or more	<u>97</u>	<u>88</u>	<u>90.72</u>	<u>9</u>	<u>9.28</u>	0.86
TOTAL	1,007	884	87.79	123	12.21	

Table 9 on page 24 was included to demonstrate the morphologic variations encountered in the treatment of these 1,007 cases. Information concerning the numbers of canals treated in each of the various tooth types is summarized.

TABLE 9  
Distribution of Morphologic Variations

	<u>Number of Canals</u>				<u>% of Canals</u>			
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
<u>Maxillary</u>								
Central Incisors	153	0	0	0	100.00	0.00	0.00	0.00
Lateral Incisors	158	0	0	0	100.00	0.00	0.00	0.00
Canines	39	0	0	0	100.00	0.00	0.00	0.00
1st Premolars	5	70	0	0	6.66	93.34	0.00	0.00
2nd Premolars	45	34	0	0	56.96	43.04	0.00	0.00
1st Molars	0	2	94	4	0.00	2.00	94.00	4.00
2nd Molars	<u>0</u>	<u>3</u>	<u>30</u>	<u>1</u>	0.00	8.82	88.24	2.94
TOTAL	400	109	124	5				
<u>Mandibular</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
Central Incisors	54	2	0	0	96.43	3.57	0.00	0.00
Lateral Incisors	21	0	0	0	100.00	0.00	0.00	0.00
Canines	12	1	0	0	92.31	7.69	0.00	0.00
1st Premolars	44	3	0	0	93.62	6.38	0.00	0.00
2nd Premolars	52	0	0	0	100.00	0.00	0.00	0.00
1st Molars	1	1	99	34	0.74	0.74	73.33	25.19
2nd Molars	<u>1</u>	<u>5</u>	<u>38</u>	<u>1</u>	2.22	11.11	84.45	2.22
TOTAL	185	12	137	35				
TOTAL NUMBER OF TREATED CASES	585	121	261	40				

## DISCUSSION

A success rate of 89.66% of the 1,770 canals treated compares very favorably with other published studies concerning the success and failure of conventional root canal therapy. The Washington Study<sup>2,3</sup> reported a success rate of 91.54% for 1,229 endodontic cases completed during the mid-1950's. Other studies have reported success rates varying from 68% to 96%.<sup>6,8,10,11,15,20,21</sup> Most of the classical endodontic literature is in agreement that a success rate of 85% to 90% is a reasonable goal that can be obtained by following sound basic endodontic principles and techniques.

The results of this study revealed a significantly lower success rate for the mandibular first molars. A success rate of 81.48% was achieved in 135 mandibular first molar cases included in this study. The most common cause of failure in root canal therapy is the problem of apical percolation.<sup>2,3</sup> The apical percolation may be caused by incomplete obturation or by failing to detect and treat one of the canals in a root. Results in Table 9 show that four canals were located and treated in 25% of the mandibular first molars included in this study. The figure of 25% with four canals is very close to the figure of 28.9% quoted by Skidmore and Bjorndal<sup>25</sup> in 1971. It appears unlikely that the lower success rate

was due to missing canals. Should one choose to speculate, it appears likely that incomplete obturation is responsible for the higher failure rate. During evaluation of these cases, the use of silver points in the canals of mandibular first molars of very young patients was observed by the investigator. It appeared in several cases that the root apices had not completed their development, thus preventing adequate sealing with the use of a silver point. Current thinking would dictate the use of apexification as detailed by Frank<sup>26</sup> to achieve mature root ends prior to obturation.

The investigator also noted many cases of failure in the mandibular first molars when silver points were exposed to the oral fluids. Placement of a proper restoration is necessary to occlusally seal the pulp chamber and to prevent dislodgement of the silver points. One can speculate that lack of a proper occlusal seal may have been responsible for some of the mandibular first molar failures. A follow-up study is needed to investigate the etiology of the 123 failed cases included in this study.

No significant differences in success rates were found when comparing the ages of the patients. This finding agrees with the studies of Strindberg<sup>4</sup> and Ingle.<sup>2,3</sup> Storms<sup>14</sup> found a higher success rate in the older patients, and he believed this was due to the narrowing of canals in older patients allowing for easier preparation and obturation. The problem of treating the open apex in very

young patients has been largely solved by the use of Frank's<sup>26</sup> apexification technique.

The results of this study indicate a significantly lower success rate of root canal therapy in males than in females. No other studies have found a sex difference in success rates of endodontic therapy. No explanation for this finding can be given.

Although the success rate for silver points was slightly lower than the success rate for gutta-percha, the difference in success rates was not significant. This finding emphasizes the fact that silver points have a very predictable success rate when they are properly indicated and used. As previously mentioned, the use of silver points in canals with immature apices frequently leads to failure. The silver points must not be disturbed once they have been cemented. A good restoration is needed to prevent occlusal leakage or displacement of the cemented points. It is interesting to note that over 56% of the canals were obturated using silver points. Current treatment rarely involves the use of silver points, since step-back techniques allow the use of gutta-percha in curved canals. However, it is comforting to know that properly used silver points have a very high success rate and their use should not be avoided when the proper indications are present.

This study clearly demonstrated that cases with preexisting pathology have a lower success rate than when no preexisting pathology was present. Numerous other studies on success and failure have all agreed that a poorer prognosis is associated with the presence of preexisting pathology at the time of treatment.<sup>4,10,11,13</sup> It must be emphasized that proper diagnosis must be used to insure that the periapical pathology is pulpal in origin. Root canal therapy will not lead to resolution of pathology not associated with pulpal disease.<sup>9</sup> This study contained no surgical cases, yet a success rate of nearly 83% was obtained in the cases with a lesion. If Bhaskar<sup>27</sup> and Lalonde and Leubke<sup>28</sup> are correct in their determination of the number of cysts present, then this study demonstrates that conventional root canal therapy can lead to resolution of periapical cysts.

The apical termination of the filling material is quite important to the prognosis of root canal therapy. Results of this study demonstrate that overfilled canals are four times more likely to fail than underfilled canals. Flush filled canals did not show a significantly higher failure rate than underfilled canals. The finding of a 36.59% failure rate for overfilled canals clearly demonstrates the need to maintain our instruments and filling materials within the confines of the root. Other studies have concluded that overfilled canals have a poorer

prognosis than canals filled short of the radiographic apex.<sup>4,10,14</sup> Materials placed outside the apex and into the periodontal tissues can cause mechanical and/or chemical irritation of the periodontal tissues preventing successful healing. Overfills actually represent an overextended filling material. The overextended filling material probably does not seal the foramen and the fill is really overextended yet underfilled.

The presence of a proper restoration is necessary to return the tooth to full masticatory efficiency, to prevent fracturing of the crown, and to occlusally seal the pulp chamber. It is unfortunate to see teeth extracted due to fracture after the successful completion of root canal therapy. It is also discouraging to see the pulp chamber exposed to oral fluids, possibly allowing these fluids to percolate apically. The failure rate was almost twice as high in cases without an adequate restoration compared to cases with a proper restoration. Weine<sup>23</sup> has indicated that more "endodontically treated teeth are lost because of fracture due to improper restorations than because of poor endodontic results." Many of the failures in this study were due to improper restorations—dowel perforations, nonrestorable crowns, and silver points exposed to the oral fluids were noted in many cases. The dentist must emphasize to the patient that a proper restoration is a necessary part of the successful treatment regimen.

The routine recall of these patients indicates that many who are comfortable do not return for recall examination. One may speculate, however, that the sample population in this study might have a lower success rate than the total population receiving root canal therapy at West Virginia University from 1959 to 1979. Patients are encouraged to notify the Department of Endodontics if any problems occur. Those with problems are more likely to return for routine recalls to see if their problems can be corrected. All recall examinations are performed at no charge, and the patients are given every opportunity to keep the Department of Endodontics informed about any failures. Even in a dental school atmosphere, it is still a difficult problem to maintain a good endodontic recall system.

Table 9 on page 24 is included to allow the evaluation of the various canal morphology variations treated in this study. The dentist must have a good working knowledge of canal morphology of the various teeth in order to avoid failures resulting from unfilled canals.

A detailed investigation of the failures in this study is needed to determine the most frequent causes of failure. Identification and elimination of these problems can only increase an already impressive success rate.

## SUMMARY

The primary goal of this study was to determine the degree of success or failure of conventional root canal therapy performed at the West Virginia University School of Dentistry from 1959 to 1979.

Recall radiographs of 1,007 teeth with 1,770 canals were evaluated for success or failure. The results of this study reveal that 89.66% of the 1,770 canals received a successful evaluation based on the criteria of Bender et al.<sup>12</sup>

Evaluation of several variables associated with the cases suggests that a lower success rate is associated with overfilled canals, canals with preexisting pathology, and teeth that are not properly restored following completion of the root canal therapy. A significantly lower success rate was also found in male patients and mandibular first molars in this study. No significant difference in success rate was found when evaluating the age of the patient or type of filling material.

## CONCLUSIONS

The data supported the following conclusions concerning the success or failure of root canal therapy completed at the West Virginia University School of Dentistry from 1959 to 1979:

1. Success was achieved in 89.66% of the 1,770 canals included in this study.
2. Success was achieved in 87.79% of the 1,007 teeth (all of the canals successful in a multi-canal tooth).
3. Mandibular first molars had a significantly lower success rate than the other teeth. The dentist should make sure that all the canals are located, thoroughly debrided, and completely obturated to achieve a good success rate.
4. The age of the patient at the time of treatment had no significant effect on success or failure.
5. Success was achieved in a significantly higher percentage of females than males.
6. The type of filling material (gutta-percha or silver) had no significant effect on success or failure.
7. The presence of preexisting pathology was associated with a significantly lower success rate than when no pathology was present.

8. Overfilled canals had a significantly lower success rate than canals filled flush or short of the radiographic apex. Dentists should be extremely careful to avoid overfills which had a failure rate nearly four times greater than the failure rate of canals filled short of the radiographic apex.
9. Failure to properly restore an endodontically treated tooth was associated with a significantly lower success rate than teeth with a proper restoration. Dentists should consider the final restoration to be an integral and crucial part of the ultimate goal of retaining the endodontically treated tooth.
10. The success rate achieved at West Virginia University is excellent and compares very favorably with success rates published in other major studies of success and failure of root canal therapy.

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## APPENDIX I

## ABSTRACT

Various investigators have published success rates for conventional root canal therapy ranging from 48% to 99%. The success rate of root canal therapy completed during a twenty-year period at the West Virginia University School of Dentistry was determined in this study.

Recall radiographs of 1,007 teeth with 1,770 canals were evaluated to determine the success or failure of endodontic therapy completed on these teeth. The patients were questioned to determine if any clinical symptoms were present prior to exposing the recall radiograph(s). Recall radiographs were taken a minimum of one year after obturation and at intervals of two years, three years, and five or more years. The following data was recorded for each tooth: 1) age and sex of the patient, 2) tooth number, 3) number of canals treated, and 4) presence or absence of a proper restoration. Type of filling material, presence or absence of preexisting pathology at time of treatment, and apical termination of the filling material were recorded for each canal.

Endodontic therapy was evaluated for success or failure by noting any patient response to questioning and examining the recall radiographs with a viewbox and magnifying glass. Cases were judged successful when the patient was asymptomatic, the tooth was functional, and

the radiograph revealed a resolved or arrested area of pathology after a posttreatment interval of one year or longer.

Data was tabulated and a success rate of 89.66% was found for the 1,770 canals. Since one failing canal dictated a multicanal tooth to be judged a failure, the success rate for the 1,007 teeth was slightly lower at 87.79%. Chi-square analysis was performed to determine if any of the treatment variables had a significant effect on success or failure. Mandibular molars had a significantly lower success rate than the other tooth types. Presence of preexisting pathology at the time of treatment, overfilling a canal, and lack of a proper posttreatment restoration were associated with a significantly lower success rate. Males in this study also demonstrated a significantly lower success rate than females. The age of the patient and the type of filling material had no significant effect on success or failure.

The success rate achieved at West Virginia University is excellent and compares very favorably with success rates published in other major studies regarding endodontic success and failure.

Accession For	By	Availability Codes	Avail and/or
NTIS GRA&I	Distribution/		Special
DTIC TAB			
Unannounced			
Justification			

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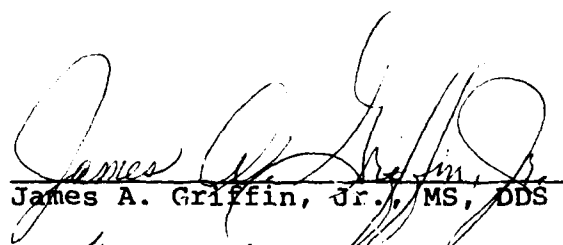
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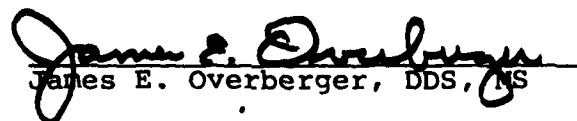
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